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(54) Title: **INHIBITION OF HAIR GROWTH**

(57) Abstract

Mammalian hair growth is reduced by applying to the skin a composition including an inhibitor of protein kinase C.

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INHIBITION OF HAIR GROWTH

The invention relates to a method of reducing unwanted hair growth in mammals, and to a cosmetic method for this purpose.

5 A main function of mammalian hair is to provide environmental protection. However, that function has largely been lost in humans, in whom hair is kept or removed from various parts of the body essentially for cosmetic reasons. For example, it is generally preferred 10 to have hair on the scalp but not on the face.

Various procedures have been employed 15 to remove unwanted hair, including shaving, electrolysis, depilatory creams or lotions, waxing, plucking, and therapeutic antiandrogens. These conventional procedures generally have drawbacks associated with them. Shaving, for instance, can cause nicks and cuts and can also promote the perception of an increase in the 20 rate of hair regrowth. Shaving also can leave stubble. Electrolysis, on the other hand, can keep a treated area free of hair for prolonged periods of time, but can be expensive, painful, and sometimes leaves scarring. Depilatory 25 creams, though very effective, typically are not recommended for frequent use due to their high irritancy potential. Waxing and plucking can

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cause pain, discomfort, and/or removal of short hair. Finally, antiandrogens -- which have been used to treat female hirsutism -- can have unwanted side effects.

5 It has previously been disclosed that the rate and character of hair growth can be altered by applying to the skin inhibitors of certain enzymes. These include inhibitors of 5-alpha reductase, ornithine decarboxylase, S-
10 adenosylmethionine decarboxylase, gamma-glutamyl transpeptidase, and transglutaminase. See, for example, Breuer et al., U.S. Pat. No. 4,885,289; Shander, U.S. Pat. No. 4,720,489; Ahluwalia, U.S. Pat. No. 5,095,007; Ahluwalia et al., U.S. Pat. No. 5,096,911; Shander et al., U.S. Pat. No. 5,132,293; and Shander et al., U.S. Pat. No. 5,143,925.

15 It has now been found that unwanted mammalian (including human) hair growth -- particularly androgen-stimulated hair growth -- can be inhibited by applying to the skin a composition including a protein kinase C ("PKC") inhibitor in an amount effective to reduce hair growth. The unwanted hair growth which is
20 reduced may be normal hair growth, or hair growth that results from an abnormal or diseased condition.

25 PKC is a phospholipid-dependent, calcium-sensitive family of enzymes that have the ability to phosphorylate proteins. PKC includes an ATP binding site, a calcium binding site, and a region which interacts with phospholipid. Preferred inhibitors of PKC include those inhibitors that interact with one or more of these specific binding sites.

30 Among the inhibitors of PKC that can be used are (1) isoquinoline sulfonamides such

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- as 1-(5-isoquinolinyl sulfonyl)-2-methylpiperazine and its derivatives (J. Biol. Chem. 264:810-815, 1989); (2) bisindolylmaleimides such as 3-[1-(3-dimethylamino)propyl]-1H-indol-3-yl]-4-(1H-indol-3-yl)-1H-pyrole-2,5-dione monohydrochloride (GF109203X), Ro 31-7549, and derivatives of Ro 31-7549 (Biochem. J. 294:335-337, 1993; J. Biol. Chem. 266:15771-15781, 1991; and J. Invest. Dermatol. 100:240-246, 1993); (3) phenothiazine derivatives such as thioridazine, trifluoperazine, and triflucarbine (J. Dermat. Sci. 4:18-25, 1992; and J. Biol. Chem. 255:8378-8380, 1980); (4) lysosphingolipids such as sphingosine and derivatives of sphingosine (Science 235:670-674, 1987; and Ann. Rev. Pharmacol. Toxicol. 32:377-397, 1992); (5) staurosporine, and derivatives of staurosporine such as 7-oxostaurosporine and 11-hydroxystaurosporine (Carcinogenesis 13:355-359, 1992; J. Antibiot. 45:195-198, 1992; and J. Org. Chem. 57:6327-6329, 1992); (6) verapamil, phentolamine and imipramine (J. Biol. Chem. 255:8378-8380, 1980); (7) L-ascorbic acid 6-palmitate (Cancer Res. 47:6633-6638, 1987); (8) glycyrrhetic acid glycoside and 18 β -glycyrrhetic acid (Cancer Letters 49:9-12, 1990); (9) polymyxin B, sangivamycin, and doxorubicin-Fe(III) (J. Dermat. Sci. 4:18-25, 1992; J. Biol. Chem. 263:1682-1692, 1988; and Trends in Pharmacol. Sci. 12:188-194, 1991); (10) the fungal product, balanol, isolated from Verticillium balanoides (J. Am. Chem. Soc. 115:6452-6453, 1993); (11) substituted indolocarbazoles (Bio rg. Med. Chem. Let. 3:1959-1964, 1993); (12) 2-(aminomethyl)piperidines (J. Med. Chem. 34:2928-

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2931, 1991); (13) curcumin (FEBS Letters 341:19-
22, 1994); (14) 4-propyl-5(4-pyridinyl)-2-(3H)-
oxazolone (Cancer Research 52:1195-1200, 1992);
and (15) dequalinium (Trends in Pharmacol. Sci.
5 12:188-194, 1991). The inhibitors can be
irreversible or reversible (competitive and
non-competitive).

The inhibitor of PKC preferably is
incorporated in a topical composition which
10 includes a non-toxic dermatologically acceptable
vehicle or carrier which is adapted to be spread
upon the skin. Examples of suitable vehicles
are acetone, alcohols, or a cream, lotion, or
gel which can effectively deliver the active
15 compound. One such vehicle is disclosed in co-
pending application PCT/US 93/0506A. In
addition, a penetration enhancer may be added to
the vehicle to further enhance the effectiveness
of the formulation.

20 The concentration of the inhibitor in
the composition may be varied over a wide range
up to a saturated solution, preferably from 0.1%
to 30% by weight or even more; the reduction of
hair growth increases as the amount of inhibitor
25 applied increases per unit area of skin. The
maximum amount effectively applied is limited
only by the rate at which the inhibitor
penetrates the skin. Generally, the effective
amounts range from 100 to 3000 micrograms or
30 more per square centimeter of skin.

35 The composition should be topically
applied to a selected area of the body from
which it is desired to inhibit hair growth. For
example, the composition can be applied to the
face, particularly to the beard area of the
face, i.e., the cheek, neck, upper lip, and
chin. The composition can also be applied to

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the legs, arms, torso or armpits. The composition is particularly suitable for reducing the growth of unwanted hair in women suffering from hirsutism or other conditions.

- 5 In humans, the composition should be applied once or twice a day, or even more frequently, for at least three months to achieve a perceived reduction in hair growth. Reduction in hair growth is demonstrated when the frequency of
10 hair removal (shaving, tweezing, depilatory use, waxing) is reduced, or the subject perceives less hair on the treated site, or quantitatively, when the weight of hair removed by shaving (i.e., hair mass) is reduced.
15 Benefits of reduced hair removal frequency include convenience and less skin irritation.

Male intact Golden Syrian hamsters are considered acceptable models for human beard hair growth in that they display oval shaped
20 flank organs, one on each side, each about 8 mm. in major diameter, which grow thick black and coarse hair similar to human beard hair. These organs produce hair in response to androgens in the hamster. To evaluate the effectiveness of a
25 particular PKC inhibitor, the flank organs of each of a group of hamsters are depilated by applying a thioglycolate based chemical depilatory (Surgax). To one organ of each animal 10-25 µl. of vehicle alone once a day is
30 applied, while to the other organ of each animal an equal amount of vehicle containing a PKC inhibitor is applied. After thirteen applications (one application per day for five days a week), the flank organs are shaved and
35 the amount of recovered hair (hair mass) from each is weighed. Percent-reduction of hair growth is calculated by subtracting the hair

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mass (mg) value of the test compound treated side from the hair mass value of the vehicle treated side; the delta value obtained is then divided by the hair mass value of the vehicle treated side, and the resultant number is multiplied by 100.

The above-described assay will be referred to herein as the "Golden Syrian hamster" assay. Preferred compositions provide an inhibition in hair growth of at least about 10 35%, more preferably at least about 50%, and most preferably at least about 70% when tested in the Golden Syrian hamster assay.

A number of PKC inhibitors were tested 15 in the Golden Syrian hamster assay; the results are presented in Table I.

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TABLE I

Compound	Vehicle ^a	Dose	pH	Hair Mass (means ± SEM)		% Inhibition
				Untreated	Treated	
Verapamil	A	10%	5.5	1.45±.12	0.43±.05	69±5
Thiridazine	A	10%	4.5	2.41±.19	0.74±.07	68±4
Curcumin	C	10%	5.5	1.66±.19	0.55±.11	68±5
Trifluoperazine	A	10%	7.5	2.38±.25	1.03±.16	56±6
H-7 ^b	A	10%	6.0	1.76±.18	0.81±.08	54±3
L-Ascorbic acid 6-palmitate	A	10%	8.5	2.82±.31	1.48±.14	46±5
Glycyrrhetic acid glycoside	A	10%	4.0	1.84±.19	0.94±.17	46±10
18 β -Glycyrrhetic acid	B	7.5%	7.5	2.01±.22	1.07±.10	44±6
Imipramine	A	10%	5.5	1.52±.22	0.94±.18	38±5
Phentolamine	A	10%	6.0	2.05±.27	1.61±.22	19±9

^aVehicle A includes pure water (68%), ethanol (16%), propylene glycol (5%), dipropylene glycol (5%), benzyl alcohol (4%) and propylene carbonate (2%); vehicle B includes ethanol (80%), pure water (10%) and dipropylene glycol (10%); and vehicle C includes acetone (40%), ethanol (20%), DMSO (20%), and water (20%).

^bH-7 is 1-(5-isooquinolinylsulfonyl)-2-methylpiperazine.

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PKC activity was assayed in hair follicles isolated from flank organs using a commercial assay kit obtained from GIBCO BRL (Gaithersburg, MD). The assay is based on the phosphorylation (incorporation of 32 -P into) of acetylated-myelin basic protein. After isolation, the flank organ hair follicles were washed in phosphate-buffered saline and homogenized in a buffer containing 20 mM Tris, pH 7.5, 0.5 mM EDTA, 0.5% Triton X-100, 10 mM β -mercaptoethanol, and 25 μ g/each of the protease inhibitors aprotinin and leupeptin. The hair follicle homogenate was added to the PKC reaction mixture at a final concentration of 10-20 μ g/assay. The assay also included buffer, H₂O, phospholipid. The assay was performed in the presence or absence of select PKC inhibitors. The reaction mixture volume was 50 μ l, the 32 P-ATP substrate was added in a volume of 10 μ l. The reaction proceeded at 32° for 15 minutes, whereupon a 16.3 μ L aliquot was removed from the reaction mixture and spotted onto a paper filter. Filters were washed twice in 1% phosphoric acid with gentle shaking for 5 minutes. Filters were then washed twice in H₂O and placed in scintillation vials. 32 P-Incorporation, a measure of the enzyme activity, was determined using standard liquid scintillation techniques. A significant inhibition was observed with thioridazine (30% inhibition at 500 μ M) and trifluoperazine (42% inhibition at 500 μ M) -- which are thought to interfere with the phospholipid binding site -- as well as with H-7, the most selective f PKC inhibitor and ATP binding site antagonist. An 86% inhibition of phosphorylation due to inhibition of PKC activity was produced by 200

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μ M H-7. Inhibition of PKC activity was nearly 100% with glycyrrhetic acid glycoside (glycyrrhizine) at 200 μ M; and 52% with 18 β -glycyrrhetic acid at 500 μ M.

5 It will be appreciated by those skilled in the art that the invention can be performed within a wide range of equivalent parameters of composition and conditions without departing from the spirit or scope of the
10 invention or of any embodiment thereof.

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C L A I M S

1. A method of inhibiting mammalian hair growth, comprising
 - 5 selecting an area of skin from which reduced hair growth is desired; and
 - 10 applying to said area of skin a composition of an inhibitor of protein kinase C in an amount effective to reduce hair growth.
- 15 2. The process of claim 1, wherein said inhibitor is verapamil.
3. The process of claim 1, wherein said inhibitor is thioridazine.
4. The process of claim 1, wherein said inhibitor is curcumin.
- 15 5. The process of claim 1, wherein said inhibitor is trifluoperazine.
6. The process of claim 1, wherein said inhibitor is 1-(5-isoquinolinylsulfonyl)-2-methylpiperazine.
- 20 7. The process of claim 1, wherein said inhibitor is L-ascorbic acid 6-palmitate.
8. The process of claim 1, wherein said inhibitor is glycyrrhetic acid glycoside.
9. The process of claim 1, wherein said 25 inhibitor is 18 β -glycyrrhetic acid.
10. The process of claim 1, wherein said inhibitor is imipramine.
11. The process of claim 1, wherein said inhibitor is phentolamine.
- 30 12. The process of claim 1, wherein said inhibitor is an isoquinoline sulfonamide.
13. The process of claim 1, wherein said inhibitor is a bisindolylmaleimide.
14. The process of claim 1, wherein said 35 inhibitor is a phenothiazine derivative.
15. The process of claim 1, wherein said inhibitor is a lysosphingolipid.

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16. The process of claim 1, wherein said inhibitor is a staurosporine.
17. The process of claim 1, wherein said inhibitor is selected from the group consisting of polymyxin B, sangivamycin, and doxorubicin-Fe(III).
18. The process of claim 1, wherein said inhibitor is balanol.
19. The process of claim 1, wherein said inhibitor is a substituted indolocarbazole.
20. The process of claim 1, wherein said inhibitor is a 2-(aminomethyl)piperidine.
21. The process of claim 1, wherein said inhibitor is 4-propyl-5(4-pyridinyl)-2-(3H)-oxazolone.
22. The process of claim 1, wherein said inhibitor is dequalinium.
23. The process of claim 1, wherein said inhibitor interacts with the ATP binding site in PKC.
24. The process of claim 1, wherein said inhibitor interacts with the calcium binding site in PKC.
25. The process of claim 1, wherein said inhibitor interacts with the region in PKC which interacts with phospholipid.
26. The process of claim 1, wherein said inhibitor is an irreversible inhibitor.
27. The process of claim 1, wherein the concentration of said inhibitor in said composition is between 1% and 30%.
28. The process of claim 1, wherein the composition is applied to the skin in an amount of from 100 to 3000 micrograms of said inhibitor per square centimeter of skin.
29. The process of claim 1, wherein the composition is applied to the skin in the face

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f said mammal.

30. The process of claim 1, wherein the composition provides a reduction in hair growth of at least 30% when tested in the Golden Syrian hamster assay.

5 31. The process of claim 1, wherein the composition provides a reduction in hair growth of at least 50% when tested in the Golden Syrian hamster assay.

10 32. The process of claim 1, wherein the composition provides a reduction in hair growth of at least 70% when tested in the Golden Syrian hamster assay.

15 33. The process of claim 1, wherein said mammal is a human.

34. The use of an inhibitor of protein kinase C for the manufacture of a medicament for inhibiting mammalian hair growth.

20 35. The use according to claim 34, wherein said inhibitor is as defined in any one of claims 2-26.

25 36. A method of producing a composition for inhibiting mammalian hair growth, which comprises selecting an inhibitor of protein kinase C, and combining said inhibitor, in an amount effective to reduce hair growth, with a non-toxic, dermatologically acceptable vehicle or carrier.

30 37. A method according to claim 36, wherein said vehicle or carrier is adapted to be spread upon the skin of a mammal.

38. A method according to claim 36, wherein said inhibitor is as defined in any one of claims 2-26.

35 39. The new use f an inhibitor of protein kinas C for reducing hair growth.

40. A compositi n when used for inhibiting

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mammalian hair growth, which includes an inhibitor of protein kinase C in an amount effective to reduce hair growth and a non-toxic, dermatologically acceptable vehicle or carrier.

- 5 41. A composition according to claim 40, wherein said inhibitor is as defined in any one of claims 2-26.